

Workshop Without Walls: Upstairs Downstairs

Breakout Group 1 Note-taking

- If you want to detect life, you need a model of what a planet looks like w/o life. For Earth, it's hard because life is there (and was there for most of the time, i.e. most of the geological record)! What's needed to have such a model? **The Dead Earth Project.**
 - Earth's future will be lifeless. Run forward models starting from now? Simulations involving biosphere collapse. Can you get back to an Archean Earth this way?
 - But that's different, because the biosphere was there at some point. What would the difference be b/w "life never happens" and "life collapses" scenarios? When modeling planets, we usually don't care about their history, but we should. How much do initial conditions matter? How much does the lifespan of the biosphere matter?
 - Without photosynthesis, O₂ would disappear in its short residence time of ~3 Myr. W/o biological sources or sinks.
 - If everything dies and decomposes, how long would the gas signature take to disappear?
 - The biosphere can do different things, depending on dominant metabolisms. Aerobic vs. not, etc.
 - Early Earth before life. We have data from zircons. But absence for evidence of life is not evidence that life was absent back then...
 - Question isn't "was there life or not?", but "was there enough life to make a difference to the atmosphere?" "Planet w/o life" could be defined as "planet w/o life as a driver" (of atmospheric composition)
 - Before O₂ photosynthesis, we may have had methanogens. Problem is, CH₄ is present in many other places in the solar system. Hydrothermal processes make it! Not just that abiotic background are unknown, but also how life also influences these processes.
 - Atmospheric composition during major extinction events? Does the microbial biosphere even care about such events? To which extent is it affected? Life might have made it through the "late" "heavy" bombardment...
- This ties to timescales of volatile recycling.
- We see great differences b/w terrestrial planets, yet assume terrestrial exoplanets are all similar in composition.
 - These exoplanets seem like they could be as different as Earth, Venus, Mars from each others, but presumably not much more different.
 - Yet the link b/w star and planet composition is very rudimentary at this point.
 - Venus and Mars' atmospheres, without life, look the same, despite different bulk compositions.

- Where does the atmosphere come from? Degassed from the interior? Late delivery? These are huge questions.
- Volatile cycling b/w surface and interior as necessary for life.
 - Influenced by bulk compositions. How many deviations from stellar composition do you need until you can say it's due to life?
 - From 1 pixel, we may not be able to see differences b/w elemental fractionations between different planetary reservoirs.
- From single-pixel observations, you get (1) time-varying information (latitudinal maps), (2) much better compositional info than from transit spectroscopy, because stellar spectra don't come into play, (3) obliquity, (4) ocean glints.
 - But beta-Pic b rotates in 8 hours. cadence of observations would need to be high, and we're not getting enough photons for such high-cadence observations.
 - Resolved observations would require telescope arrays spanning significant space in the solar system!
 - Currently, we can image either big planets, or planets far from their star. Stellar separation matters. Starshades flying in tandem with the telescope (~40000 km away) would allow you to get closer in to the star.
 - Will we know which targets to observe before WFIRST or some other asset comes online, or will we need to schedule a survey phase first? Perhaps using a coronagraph, then starshade for targeted observations.
 - Could glints also be due to ice, or geysers? Are glints polarized? Seems like they are specific to oceans. Doesn't tell us anything about the liquid composition (H₂O on Earth, hydrocarbons on Titan).
- So, does composition matter?
 - With 1 data point, life and plate tectonics are correlated. Plate tectonics could be very sensitive to composition. Perhaps other means of volatile cycling aren't.
 - Rheology is sensitive to composition.
 - Parallels with patterns on Pluto and Europa. How deep does the material go on Europa?
 - Drake equation of plate tectonics?
 - Water is not sufficient to get plate tectonics. Life could be necessary for it. Need sufficiently strong surface material (compared to e.g. Venus)
 - What's the recipe for making a habitable planet? Specific processes at just the specific time?
 - Crustal weakening timescales: depend on temperatures and composition. On Earth: 10s of Gyr. On Venus: < Myr?